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Food Security Submission**The Politics of Plants**

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Abstract

Food security is not a new concern, but has taken on new dimensions in recent years. Here we position food security in a broader context relating to the use and management of global biomass resources, and specifically the push to develop a ‘bio-based economy’. We note a growing focus on plants as a source of innovative solutions to complex problems including food security, energy security, climate change and global environmental health. However, we also note that plants are a renewable but finite resource, and propose that renewed enthusiasm for plants is resulting in an increasingly complicated ‘politics of plants,’ as competition for limited land and biomass resources intensifies — the clash between food security and energy security over biofuels being an obvious example. Plants are a common thread across policy domains including agriculture, energy, environment, health, and industry, and as such we suggest that they might provide a focal point for joined-up thinking and governance. We identify this broader picture as an important backdrop for discussions regarding food security, and from our proposed framework develop a number of recommendations for further investigation.

Keywords

Bioeconomy; biofuels; biotechnology; food security; plant science; research policy

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Food security is not a new issue, but has recently taken on new dimensions and is currently a matter of great concern. In recent decades considered a problem predominantly for developing countries, food availability and distribution is again climbing up the policy agendas of developed nations, in relation to a variety of geopolitical and environmental factors (Defra 2006; von Braun 2007a). In this article, we propose to relate food security to the use and management of global biomass resources, and specifically the push to develop a sustainable ‘bio-based economy’ (see below). There is a growing focus on plants — and particularly plant biotechnology — as a source of innovative solutions to complex problems including food security, energy security, climate change and global environmental health. We propose that this enthusiasm for plants is also resulting in an increasingly complicated ‘politics of plants,’ as competition for limited land and biomass resources intensifies. We see the politics of plants as an important consideration in food security discussions, and furthermore suggest that plants might provide a common entry point for joined-up thinking on research and policy matters relevant to the range of interconnected (but often artificially separated) issues listed above. In developing this position, we have engaged in a series of highly interdisciplinary meetings over a two-year period, involving academics from a wide range of natural and social science disciplines, as well as representatives from government bodies and non-governmental organizations. Here we draw on these discussions to present a case for the emerging politics of plants, and to argue its relevance for discussions of food security.

Plants and the Bio-Based Economy

Plants are the bedrock of food and energy production. The management of plants, as a link between the economy, human health and the environment, is in many ways taken for granted, particularly in developed nations. However, the critical position of plants has been increasingly recognized in recent years, largely through policy-level attention to the concept of the ‘knowledge-based bioeconomy’ (OECD 2006; European Commission 2005). Although working definitions differ, in a bioeconomy the raw materials and basic building blocks for food, energy, industry, growth and well-being are derived from biological, renewable resources (mainly plants and microorganisms). Arguably, humans have always had a bioeconomy, being largely dependent on biological resources for nourishment, clothing, shelter, and so on — even the fossil fuel economy obtains energy from ‘ancient sunlight’. However, current thinking emphasizes the use of cutting-edge science and technology to support the transition away from a petroleum-based economy to one dependent on bio-renewables (European Plant Science Organization 2005). As noted by the European Commission (2005), “although plants are not most people’s idea of high technology, much of the knowledge-based bioeconomy is firmly rooted in the plant sciences” (p.11).

Plants are thus capturing the interest of businesses, researchers and policymakers worldwide. Although plant science research suffered in terms of profile and funding in the 1980s and 1990s, the possibilities being opened up by modern biotechnology are leading to renewed enthusiasm — and funding to match. For example, the knowledge-based bioeconomy is a cross-cutting theme in the European Commission's latest round of research funding (the €1.75 billion Framework Programme Seven, FP7)¹. From cellulosic bioethanol to pharmaceutical 'biofactories', phytoremediation devices, and large-scale 'biorefineries', some of the impending applications for plants extend far beyond their traditional uses.

As potentially environmentally sustainable commodities, the enthusiasm for plant-derived products is understandable. Tantalizingly, they might offer a way out of the zero-sum game between economic growth and environmental protection (World Commission on Environment and Development 1987). In principle, a deeper understanding of plants and other living systems could allow us to better manage the earth's resources for both environmental and economic ends. But are we likely to reach such a win-win situation? The re-valuing of plants in terms of their technological potential is exposing tensions among the many different systems to which plants contribute. Demand for land, water and biomass resources is intensifying, with consequences (notably, higher food prices) that are being felt by all. If current developments are anything to go by, the politics of plants will quickly become increasingly complicated.

Competing Visions

The vision of a bio-based economy grounded in principles of sustainability and environmental health is powerful in part because it speaks to groups with quite different motivations and priorities — there seems to be something in it for everyone. This can be both a strength and a weakness: a strength in that it provides a space for interdisciplinary dialogue, but a weakness because the concept can become 'toothless' with regards to action (an accusation sometimes made of the sustainable development agenda, Fischer and Black 1995), or be captured by a particular set of interests but still purport to speak to all.

Drawing on a rapidly growing collection of documents, we are able to identify a number of issues feeding into the rhetoric of the bioeconomy and the growing interest in plant systems. Food security is core among these, as are climate change, global environmental health, energy supply and security, the industrial economy, health and well-being, and farming and the rural economy (see Table 1). As

¹See http://ec.europa.eu/research/biosociety/kbbe/kbbe_en.htm.

readers of this journal are no doubt only too aware, there are clearly strong and quite complex connections among many of these issues. We propose that this categorization provides a useful structure for mapping the emerging politics of plants, and for identifying research and policy needs. Current research questions and policy initiatives are frequently tied to relatively isolated priorities. However, developing integrated solutions to interrelated problems requires a certain attention to the dynamics of the larger system, and our aim in Table 1 is to make explicit the many factors contributing to this system.

In addition to the plant-related objectives set out in the Table is the cross-cutting and more strategic question of national and regional competitiveness, also a key driving force in the context of the knowledge-based bioeconomy and the emerging politics of plants. Ideas of what constitutes welfare and progress, and views regarding globalization, consumption, trade, innovation and development will influence approaches to plant use — both with respect to the specific issues identified here, and more generally as countries strive to stay ahead (whatever they believe that means). Commitment to progress through technological development, together with the overlapping set of drivers listed in Table 1, are contributing to a policy rhetoric of moral imperative and inevitability associated with the plant-based bioeconomy.

Food Security and the Politics of Plants

Why should we focus on these competing visions? Although plants are renewable resources, they are also *finite* at any given time — there is only so much land, water and biomass available to accommodate many worldviews and fulfil a rapidly growing wish-list of functions. To complicate matters, seemingly isolated decisions taken at one level can have far-reaching and unanticipated consequences across a range of geographical and regulatory scales.

A topical example with which to illustrate this point focuses on the public debate over transport biofuels in past two years. This a striking example of the complexity of current plant politics, and one that might be used to explore systematically the competing visions outlined above. The US has recently taken a lead in promoting transport bioethanol production, through the 2005 Energy Policy Act and a dramatic increase in investment coupled to a number of target-oriented incentives. A record 92.9 million acres of corn was planted in the US in 2007 (up 19% from 2006; US Department of Agriculture 2007), and a third of this yield used to make bioethanol. However, biofuel development is not a closed system (although from a technological perspective some might be inclined to treat it as such), and the rapid growth of this industry has potential effects across the entire web of issues listed in Table 1.

The clash between food politics and energy politics over biofuels is becoming increasingly clear. In the short term at least, bioethanol production has had negative effects on global food security — the ‘craze for maize’ was one of the key factors linked to protests against the rising price of tortillas in Mexico in early 2007. Global corn reserves have decreased despite record harvests, and the significant increase in food prices seen over the past year is in part attributed to increased biofuel production (Anon. 2007a,b). An estimate from the International Food and Policy Research Institute suggests that approximately 30% of the increase in average grain prices from 2000 to 2007 is a result of biofuel production (von Braun 2007b). Over the past year civil unrest related to soaring food prices has been seen in over a dozen countries worldwide. In the longer term, the growing link between agricultural commodity prices and fossil fuel prices is likely to have complex effects on food production, access to food, and the stability of food supplies (Schmidhuber 2007). However, with a “perfect storm of political attention” (Russo 2006, p.648) initially focused on oil prices, climate change and the possibility of economic growth through developing biofuel technologies, the scale of the conflict between food and fuel was perhaps underestimated by those keen to promote industrial-scale production of biofuels.

The effects of US investment in biofuel production extend beyond food security, to encompass the entire range of policy domains listed in Table 1. To touch on each of these briefly, the effects on energy security and stimulation of the US rural economy have thus far been positive. Private investment in biofuels and related industrial processing technologies is booming, with oil companies setting up public–private research partnerships at US universities, and venture capital investment in biofuels topping US \$740 million in 2006 (Waltz 2007). With respect to climate change (nominally a key motivating factor for bioenergy development), the effects of biofuel production are not clear-cut. Although estimates vary, maize is certainly not the ‘greenest’ biofuel in terms of CO₂ emissions reduction (International Energy Agency 2004). Ambitious targets for biofuel consumption are already leading to changes in land use worldwide, as countries respond to their own targets or see an export opportunity (Fargione et al. 2008). The consequences of land-use changes are complex, with recent models suggesting that global greenhouse gas emissions are likely to *increase* as a result of the land conversion necessary to meet US demand for biofuels (Searchinger et al. 2008). In September 2007, the European Union (EU) promoted land conversion by suspending the farming set-aside scheme established in the 1980s to limit surplus cereal production. Although the economic benefits of growing biofuel crops on set-aside land might be obvious (EU set-aside arable land amounted to 3.8 million hectares in 2007), the effects of this policy change on local biodiversity and agroecosystem health remain to be seen.

Although these are some of the macro-scale consequences of biofuel development, they are played out in myriad ways right down to the most local and individual level. The challenges for governance are obvious but daunting. Hasty target-setting is problematic, but inertia is not an option either. The biofuels scenario highlights the need to develop models that are sensitive to a variety of social, economic, political and environmental factors. A systems perspective should be incorporated into the design of targets, incentives and instruments that are flexible and process-oriented. Pilot-scale experiments should be encouraged and eligible for public funding, and outcomes should be evaluated in relation to the issues listed in Table 1. Sustainability is not a static endpoint but a process, and for a sustainable bioeconomy the means are therefore just as important as the ends.

Similar systems thinking also applies to food security initiatives. There are a wide range of approaches that might be adopted to improve food security. For example, emphasis might be placed on increasing crop yield through the development of improved varieties (using biotechnology or other means), through improved irrigation or farm management schemes, through use of fertilizers or pesticides, and so on (Briggs 1998; Huang et al. 2002; Tilman et al. 2002). Increased food security might also be pursued through a strategy of improving the nutritional value of food (Morris & Sands 2006). A third option might be to increase the land area under cultivation, particularly to include ‘unproductive’ or ‘marginal’ land. Food security might also be improved by addressing infrastructure needs and trade policies relating to food production and distribution. In light of the above discussion, it seems advisable to evaluate any proposed large-scale changes to food production in relation to possible consequences for the entire range of issues in Table 1. Current food production and distribution systems should also be assessed according to these criteria. Adopting a more systems-oriented approach should help to minimize conflicts or detrimental effects among many competing priorities, and may identify useful areas for future research. In order to extend a systems approach effectively across the range of issues identified here, we must develop more sophisticated and integrated models for resource management, and for understanding and predicting social, environmental and economic responses to changes in biomass composition, distribution and use at different scales.

Moving forwards

We have outlined a way of framing and thinking about a wide range of interconnected and politically charged issues associated with plants and the emerging bioeconomy. It is necessarily a general framework, but can serve as the basis for making systematic assessments of possible scenarios. Several implications for research and policy agendas derive from this.

Implicit in descriptions of the knowledge-based bioeconomy is that we are moving from a resource-limited economy (constrained by oil reserves) to one of potentially unlimited resource in the form of biomass. The million-dollar research question is whether there is enough biomass to support the many environmental, social and economic objectives of the bioeconomy. In the short term at least, this is unlikely — we do not yet know how to optimize the potential of plants along all the dimensions listed in Table 1, and land availability is a key limiting factor at present. In order to better prioritize among competing options, we must develop a more sophisticated understanding of *what* and *where* the current limits are. Some of the issues in Table 1 are more dependent on dedicated biomass resource than others — certainly at the moment, we have no alternative sources for food or for ecosystem function. However, there are alternatives to biomass that can and are being pursued with regards to renewable and/or non-carbon sources of energy. In the face of limited land and biomass resources, short-term research and policy options could be weighted according to such criteria in order to minimize conflicts.

In the medium to long term, innovative approaches and new technologies will certainly be required. There is reason to think that we will see great improvements in our ability to derive energy and other useful materials from plants. In some ways, biotechnology is being promoted as a steadying force for the bioeconomy, one that will contribute to the goal of maximizing benefits in all dimensions at the expense of none. For example, development of cellulosic biofuels might help to relieve competition between food and fuel crops (Rubin 2008). And the interest in land-based biofuel crops might fade completely if we learn to harness the vast photosynthetic capacity of ocean life, or if synthetic biology delivers fuel-producing microbes (Waltz 2007). Multifunctionality is an important concept for the bioeconomy, but to achieve this truly interdisciplinary research is key. Research questions must be designed with wider social, economic and environmental concerns in mind, and for this we may need new and more inclusive methods of deliberation.

It is wrong to think that science and technology are a panacea, as new technologies invariably raise questions and complications of their own. (Indeed, the push to develop a technology-oriented bio-based economy is in part responsible for the emerging politics of plants. To what extent can we expect it to provide solutions?) Furthermore, even if we become able to satisfy every conceivable objective using biomass, appropriate management is a different story. To provide an obvious example in the context of food security, the world already produces enough food for all, yet over 800 million are chronically undernourished (Food and Agriculture Organization 2006). Reducing waste and inefficient biomass consumption is one way of relieving some of the current pressures; to do this effectively we may need to understand more about the influences on consumer behaviour. Questions of ownership, distribution and access will become increasingly important with respect to plants and their associated resources (land, water, etc.), and changing power relations are likely to have consequences for security

and social justice. The legal basis of rural land management may also have to change in order to reflect the changing value of plants (and land). What implications might this have for food security, or for biodiversity conservation?

Current management of plant resources is fragmented. Although it is unrealistic to think that governments will develop policies for agriculture, energy, environment, health, industry and innovation under a single roof, by providing a common thread across this spectrum of issues, plants may provide a useful entry point for joined-up thinking and governance. To achieve this, we need to create both flexible and formal spaces for discussion and coordination — within and among government departments, funding bodies, industry, research institutes and public groups, and in interdisciplinary journals. Our series of interdisciplinary meetings has attempted to promote such discussion on a very small and modest scale (Frow, in press). Establishing a national body to support and synthesize the findings from such activities would undoubtedly be a cost-effective investment for those countries aspiring to develop sustainable, bio-based economies. Encouraging international and intergovernmental dialogue will also be important for addressing the global dimensions of plant politics.

In this agenda-setting piece, we have tried to position food security in a broader context relating to the development of a bio-based economy and the emerging ‘politics of plants.’ Despite being of great concern in its own right, we see food security as deeply embedded in the debate over plant resources, and have tried to provide a constructive way of thinking about the management of plants in relation to a host of pressing global issues. We hope this framing allows for, and indeed encourages, further contributions that draw on a variety of approaches. If seen as a potentially useful perspective (a point on which we would welcome comments), the challenge for all of us will be to foster communication across disciplines and policy domains, and for us to treat this growing complexity as part of the solution, not just part of the problem.

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Competing Interest Statement The authors declare that they have no conflict of interest.

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Research and Policy Domains	Core Issues	Examples of Key Goals and Activities
Climate change	<ul style="list-style-type: none"> • Global warming (and resulting effects on many aspects of human life) 	Managing the global carbon footprint (e.g. through reduction of CO ₂ emissions and carbon sequestration projects)
Environmental health	<ul style="list-style-type: none"> • Biodiversity loss • Intensive agriculture and increasing urbanization 	Conserving biodiversity, maintaining/restoring ecosystem function and nutrient cycling
Health and well-being	<ul style="list-style-type: none"> • Growing demand for food quality and safety • Growing (and ageing) world population 	Enhancing the nutritional value and safety of foods; safeguarding and enhancing spaces for leisure and recreation (domestic gardens, parks, landscapes, wilderness)
Food security and poverty reduction	<ul style="list-style-type: none"> • Growing world population • Energy- and resource-intensive agriculture • Crop damage by plant pests and pathogens • Climate change and increasing frequency of extreme weather events 	Optimizing farming yields and agroecosystem health through development projects, environmental monitoring, and agricultural biotechnology (exploiting agricultural genetic diversity)
Farming, forestry and the rural economy	<ul style="list-style-type: none"> • Pressures on rural livelihoods and community infrastructures • Economic under-valuation of ecosystem services supplied by farmers and foresters 	Supporting and revitalizing rural communities; maintaining supply of high-demand products (e.g. timber, cotton, flowers); identifying new products and specialist markets for farmers
Industrial growth and product substitution	<ul style="list-style-type: none"> • (Limited) fossil fuels are a key industrial feedstock • Markets for new (sustainable) products 	Exploiting plant and microbial genetic diversity for industrial biotechnology (e.g. identifying useful enzymes and compounds for industrial processes) and for new bio-based products
Energy supply and security	<ul style="list-style-type: none"> • Growing energy demand • High oil prices • Limited fossil fuel reserves 	Developing biomass feedstocks, conversion technologies and infrastructure for bioenergy production (large focus on transport biofuels)

Table 1 | The politics of plants. This table identifies core research and policy domains linked to the management of global biomass resources, and within these highlights some of the key issues shaping activities and attitudes towards plant use for the bio-based economy. Our intention is not to artificially segregate what are in fact deeply interconnected issues, but to show how different priorities and worldviews can lead to the development of relatively isolated research or policy initiatives. Any transition towards a more bio-based economy will involve a wide range of institutions and actors from across these many domains, and will require attention to a number of social, political, economic and environmental factors. Arguably a lack of coordination is contributing to the emerging politics of plants, and greater attention to dynamics at the systems level will be required to develop more integrated and sustainable solutions. Plants might offer a useful entry point for promoting joined-up thinking and governance.